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## Human Capital in Mexico: Estimating Externalities with the Constant-Composition Approach

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HUMAN CAPITAL IN MEXICO: ESTIMATING EXTERNALITIES WITH THE  
CONSTANT-COMPOSITION APPROACH

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By Lorin D. Dawson

A thesis presented in partial fulfillment of the requirements for completion of  
the Bachelor of Arts degree in International Studies  
and the Bachelor of Business Administration degree in Economics  
Croft Institute for International Studies  
Sally McDonnell Barksdale Honors College  
The University of Mississippi

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## **Abstract**

Understanding a country's human capital externalities is an important part of understanding economic phenomena and implementing national economic policy. However, externalities are difficult to estimate. Measurement error can cause a misinterpretation of economic models and result in misguided policies. The two methods of calculating human capital externalities are the Mincer Equation and Constant-Composition approach. The author estimates human capital externalities in Mexico with the Constant-Composition approach because the Mincer approach often finds externalities where none are present. Using the Constant-Composition method, the author finds no indication of human capital externalities in Mexico.

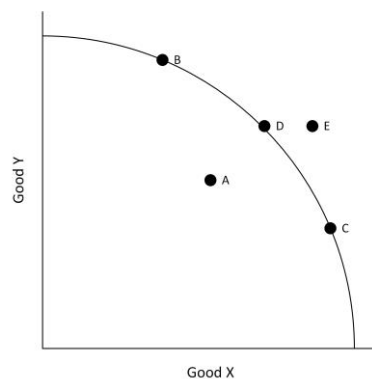
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## Introduction

Human capital is defined as the stock of knowledge, habits, and attributes embodied in the ability to perform labor to produce economic value and on an individual level. Human capital measures a person's ability to produce goods and services effectively and efficiently.

The production-possibility frontier (PPF) is a graph representing production trade-offs in an economy with fixed resources. It shows the various combinations of two commodities, or one commodity and all other goods, an economy is able to produce with capital and labor inputs held constant.



*Figure 1*

Consider the PPF Curve presented in Figure 1. Points B, D, and C represent combinations of Good X and Good Y that efficiently utilize all inputs as indicated by their position on the curve. Point A is within the curve, and inputs are not fully utilized. Since capital inputs, such as machinery, building space, etc., are difficult to change in the short-run, firms reduce labor inputs by laying-off workers or reducing their hours. In point E, the economy is operating outside of the PPF curve. An economy cannot operate outside the PPF curve in the short run because the inputs are fixed at a lower level.

Output can only be increased beyond the PPF curve if firms increase or improve inputs. This shifts the PPF curve out and results in higher production capacity for all combinations of Good X and Good Y. Human capital accumulation improves labor inputs, which consequently increases an economy's total output. Therefore, human capital is an important factor of a strong economy.

Acemoglu, Gallego, and Robinson (2014) posit that a larger initial amount of human capital caused high historical economic growth rates. Their argument states that developed countries have grown at a faster rate than currently developing and newly industrialized countries due to their larger initial human capital stock. However, this alone does not fully explain the present gap between developed countries as compared with newly developing and newly industrialized countries.

An externality is the cost or benefit that affects a party who did not choose to incur that cost or benefit (Buchanan and Stubblebine 1962). Externalities can be negative, a cost, or positive, a benefit. Air pollution is a standard example of a negative externality; research and development are examples of a positive externality. Economists measure the value of externalities by individuals' willingness to pay. If one thousand people were willing to pay one hundred dollars for cleaner air, there would be a one hundred thousand dollar air pollution externality.

Externalities are a common argument for government intervention. Externalities create a difference in the marginal social benefit and the marginal private benefit. This leads to either over or under-consumption of a good. In the case of human capital, if the

social benefit is greater than the private benefit, there will be under-investment in human capital because an individual's wage does not capture returns to social benefit. In this example, the government should subsidize education to offset the imbalance in consumption caused by externalities.

Two ways to calculate human capital externalities are the Mincer and Constant-Composition equations. This paper uses the Constant-Composition approach to test for the existence and size of externalities associated with human capital in Mexico. The analysis suggests that there is no evidence of human capital externalities in Mexico. These findings are consistent with those Ciccone and Peri (2005) found in the United States and suggest that human capital investments should not be subsidized in Mexico.

## **Literature Review**

### **Types of Human Capital**

The two main forms of human capital accumulation are schooling and on-the-job training. Both individuals and firms pay for increases in human capital through a combination of direct costs and foregone earnings (Becker 1962). Although individuals tend to emphasize direct costs, foregone earnings are often an important part of the total cost of human capital investment.

On-the-job training refers to human capital accumulation occurring at firms, which train individuals with the goal of increasing their output level. Within on-the-job training, there are two types: general and specific training. "Perfectly" general training and "perfectly" specific training lie on either end of a continuum, and in reality the



majority of on-the-job training lies somewhere on the continuum between the two ends and is thus a combination of both types.

General training is valuable in firms besides the one providing the training, and as a result, individuals pay for general training through reduced earnings. Since general training has potential to increase marginal product in all firms, the marginal product would rise by an equivalent amount in all firms. As a result, wages would rise by the same amount, and firms providing general training become unable to capture any returns. Therefore, firms only provide general training when they do not incur the costs. Individuals pay for general training by accepting wages below their productivity.

Unlike general training, specific training increases productivity only within the firm providing it. If an employee's training is completely specific, then the wage he could receive elsewhere would be independent of his training. Consequently, firms have to pay specific training costs, as no rational employee would pay for training that does not benefit him or her. This results in firms only offering training whenever the return is greater than or equal to the cost. In actuality, the willingness of firms and individuals to pay specific training costs is dependent upon turnover, and are more willing to invest in specific training when turnover is low (Becker 1962).

Schooling refers to institutions that specialize in training itself. Students earn less than if they were not in school, because students are unable to work while in school, except during vacations. Additional schooling increases wages at all firms, similar to general training, but some knowledge obtained at school can be specific in nature. For

example, an individual who studies engineering will generally receive higher wages at an engineering firm than any other type of firm.

General knowledge is another form of human capital. An important form of knowledge is on-the-job-experience (Mincer 1958). An example of knowledge through experience is that a familiarity of prices charged by different suppliers enables an employee to buy material from the cheapest alternative. Another example of general knowledge is that information on wages offered by different firms enables an individual to work at the highest paying firm. Both of these examples show that general knowledge can increase a person's command over their available resources. Moreover, knowledge not directly related to resources, such as information about different political systems or social arrangements could also benefit a person and potentially raise his wages.

### **Investing in Human Capital**

The most important determinant of human capital investment is profitability. No rational person or firm would be willing to invest in human capital unless the return at least equaled the costs of investment. If human capital investment were restricted to a single known period, the cost and rate of return could be determined solely from net earnings. However, investment in human capital is distributed over several periods so the analysis must be generalized to capture distributed income. Consider three distinct human capital investment activities X, Y, and Z. In activity X, the earning stream is flat during all periods,  $X_0 = X_1 = \dots = X_n$ , due to no investment in human capital; in activity

Y, where investment in human capital is random, a person has a real net earnings stream of  $Y_0$  during the first investment period,  $Y_1$  the next, and so on until  $Y_n$  during the last period; and in activity Z, learning is unavoidable, which causes human capital to accumulate over time so  $Z_0 < Z_n$ . This results in the real net earnings stream of  $Z_0$  being less than  $X_0$ , but during the last period  $Z_n$  is greater than  $X_n$  (Becker 1962). Essentially, activity Z results in an earnings stream similar to activity Y that grows at a slower rate. The different investment activities and combinations thereof will result in unique earnings among occupations and projected earning paths (Mincer 1958). Given the net earnings stream of these separate activities, the cost and return of human capital investments is relatively easy to calculate.

The present value of the net earnings stream in Y would be

$$V(Y) = \sum_{j=0}^n \frac{Y_j}{(1+i)^{j+1}},$$

where  $i$  is the market discount rate, assumed to be the same in each period for simplicity. The difference between net earnings streams Y and X can be used to calculate the cost and returns of investments in activity Y, summarized by the equation

$$d = V(Y) - V(X) = \sum_{j=0}^n \frac{Y_j - X_j}{(1+i)^{j+1}}.$$

This equation can be further simplified if activity Y requires an investment only in the initial period and X does not, then the cost of choosing Y rather than X is the difference between their net earnings in the initial period. The total return would be the

present value of the differences between net earnings in later periods (Becker 1962). If  $C = X_0 - Y_0$ ,  $k_j = Y_j - X_j$ ,  $j = 1, \dots, n$ , and  $R$  measures the total return, the profitability of  $Y$  can be written as

$$d = \sum_{j=1}^n \frac{k_j}{(1-i)^j} - C = R - C.$$

In a similar fashion, the profitability of activity  $Z$ , “unavoidable” learning can be calculated by substituting  $Y$  for  $Z$  in the equations above. If this “unavoidable” learning occurs can be an example of human capital externalities if the learning is occurs due to interacting with other individuals and will be discussed in more depth later on.

Another constraint for investing in human capital besides the low rate of return identified by Lucas, is time (1993). While the growth of physical capital depends on saving rate, the growth of human capital depends on the amount of quality-adjusted time devoted to its production. This concept can be summarized as

$$\frac{dh(t)}{dt} = \delta(1-u)h(t),$$

where  $h$  is human capital,  $t$  is time and  $u$  is the fraction of time people spend producing goods. For each unit of additional time an individual dedicates to producing goods, less time remains to invest in human capital.

## Human Capital and Economic Growth

On a macroeconomic level, investments in human capital contribute to increases in economic performance, mainly through higher rates of economic growth. Many economists, like Sianesi and Lucas, argue that the main engine of economic growth is human capital accumulation. These economists have adapted new growth economics, which expands the neo-classical model to capture the effects of human capital on growth. The definition of the aggregate production function, where GDP ( $Y$ ) is modeled as a function of the aggregate stock of the economy's physical capital ( $K$ ), labor force ( $L$ ), and time ( $t$ ), which captures technical progress. The definition can be written in symbols as

$$Y_t = f(K_t, L_t, t) .$$

In this definition of the production function, human capital is not included as an input. However, new growth economics emphasize endogenous determination of growth and explicitly bring the role of human capital to the fore (Sianesi 2003). The augmented neo-classical model expands the definition of the aggregate production function to include human capital and can be written as

$$Y(t) = A(t)H(t)^a L(t)^\beta K(t)^{1-a-\beta} ,$$

where  $Y(t)$  is output at time  $t$ ,  $A$  the level of technology,  $H$  the human capital stock in the labor force,  $L$  the labor force, and  $K$  the physical capital stock. Dividing the augmented neo-classical model by  $L$  yields the function

$$y(t) = A(t)h(t)^a k(t)^{1-a-\beta}$$

and expresses the model in per capita terms, where in particular  $h \equiv \frac{H}{L}$  is the stock of human capital per worker. The augmented neo-classical model shows that increases in human capital ( $H$ ) have a positive correlation with GDP ( $Y$ ) and GDP per capita ( $y \equiv \frac{Y}{L}$ ).

Lucas gives another adaptation of the neo-classical growth model that uses human capital as an input for GDP. It is as follows:

$$y(t) = Ak(t)^a[uh(t)]^{1-a},$$

where  $k(t)$  is physical capital,  $h(t)$  is human capital, and  $u$  is the fraction of time people spend producing goods (1993).

In new growth economics, there are two schools of thought which respectively focus on the effects of accumulation of human capital and the stock of human capital within the economy that have important implications for the augmented neo-classical model and Lucas' adaptation of the neo-classical model (Sianesi 2003). The first school of thought suggests any increase in human capital will have an effect on the level of output. In the second school of thought, increases in human capital will increase the economic growth rate forever. No consensus has been reached in empirical literature regarding which is the appropriate approach. Another factor that affects human capital in new growth models is the type of goods produced. If one thinks of some activities requiring a high human capital stock in the economy and others requiring a low stock, then the type of goods an economy produces will affect its overall rate of human capital accumulation and growth (Lucas 1993).

## **Human Capital Externalities**

The “unavoidable” learning through interaction described above is a consequence of human capital externalities. An externality is the consequence or spillover of an economic activity experienced by unrelated third parties. Thus, human capital externalities are the benefit or cost of changes in human capital on parties who did not choose to incur said benefit or cost.

Many forms of interaction can create human capital externalities. The theories of nonpecuniary and pecuniary externalities explore the two distinct types of interactions but lead to similar empirical relationships. The theory of nonpecuniary externalities refers to external effects of human capital that do not work through prices, but rather the exchange of ideas, imitation, or learning by doing. Since firms invest in new technology only when there is a sufficient supply of trained workers to replace employees who quit, the theory of pecuniary externalities refers to increasing wages and encouraging investments by raising human capital (Acemoglu and Angrist 2000). Externalities arise in the pecuniary theory because human capital and physical capital are compliments; hence, a more educated work force leads to greater investment in physical capital and higher wages.

Possibly one of the clearest examples of human capital externalities is the Liberty Ship Miracle (Lucas 1993). During World War II, data was collected from fourteen US shipyards that solely produced the Liberty Ship cargo vessel. Between December 1941 and December 1944, the fourteen shipyards produced 2458 Liberty Ships, all to the

same standard design. Lucas recorded the hours of labor per vessel and plotted them against the number of vessels completed. The reductions of labor hours per Liberty Ship with each doubling of cumulative output ranged from 12 to 24 percent (Lucas 1993). Although it is unclear from the evidence who is learning, it is evident that “unavoidable” learning accumulates as cumulative output increases. As individuals discover new ways to increase output, this knowledge spills over to their coworkers, creating externalities. If externalities were not present in this scenario, then only the individuals making the discoveries would increase output, not the shipyard as a whole.

### **Returns on Human Capital Externalities**

Human capital externalities can generate both private and social returns. Private returns to human capital externalities include increased productivity and a higher rate of innovation. Meanwhile, social returns can include better public health, better parenting, lower crime, a better environment, wider political and community participation, and greater social cohesion, which all positively affect economic growth (Sianesi 2003). Although most economists agree that social returns exceed private returns, it is unclear whether they do in reality. For example, if training and schooling have signaling value, social returns to human capital investment can be less than private returns. In the scenario where training and schooling do not increase human capital and serve only as a signal, aggregate income is unchanged when individuals increase their human capital, so social returns are zero (Acemoglu and Angrist 2000). Unfortunately, most analysis is only able to capture private return estimates and is unable to estimate the full returns of human capital investment on society.



The internal rate of return method, a purely accounting approach, evaluates the profitability of any given investment by looking at the investment's discounted flow of benefits and costs. The internal rate of return is the discount rate that makes the net present value of all cash flows from a particular investment equal to zero. The higher an investment's internal rate of return, the more desirable it is to undertake. Sianesi (2003) describes the social rate of return as the internal rate of return of an investment evaluated from a social point of view, or in other words, it is given by that discount rate for which the present discounted value of all social benefits equals the present discounted value of all social costs. A properly calculated social rate of return should guide a societal decision to finance human capital as a collective.

Social rates of return include all direct costs, not just those borne by the individual, of human capital investment and use pre-tax earnings; as opposed to private rates of return that assume the only cost of human capital investment is opportunity cost and uses post-tax earnings. (Sianesi 2003). Social rates of return should be considered as the lower bound of the full returns to education.

### **The Importance of Human Capital Externalities**

Understanding human capital externalities can help explain several economic phenomena. Human capital externalities help explain cross-country differences in economic development and income. If one assumes that social returns to schooling are around 10%, then top-decile countries in GDP would produce roughly double per worker compared to bottom-decile countries, however, in reality, the output per worker gap is

approximately 15. The existence of human capital externalities around 25% to 30% is sufficient to explain the difference in expected and actual output per worker (Acemoglu and Angrist 2000). In addition, externalities play a critical role in education policy, specifically when deciding to what extent human capital investments should be subsidized (Ciccone and Peri 2005). Strong externalities will result in a higher social return on investment than private return. As a result, individuals will underinvest in human capital. In this case, the government should subsidize human capital investments to encourage private investment.

Externalities might also help explain the lack of capital flows to poor countries and the effects of agglomeration on economic growth (Acemoglu and Angrist 2000). Strong externalities generate higher returns on investment and attract more investment. Poor countries generally exhibit modest human capital externalities, and therefore attract less investment. Rational individuals will not invest in these poor countries in order to obtain a higher return in developed countries, causing a lack of capital flows to poor countries and agglomeration on economic growth in developed countries.

### **Estimating Human Capital Externalities**

Several methods exist to calculate the strength of externalities. Both Sianesi, as well as Acemoglu and Angrist (2003, 2000), uses basic wage regressions to identify externalities by isolating the causal impact on individual wages of the average level of

education in the city or state of residence of the individual (2003, 2000). The equation used is

$$Y_{ijt} = X'_{i\mu} + \delta_j + \delta_t + \gamma_1 \bar{S}_{jt} + \gamma_2 s_i + u_{jt} + \varepsilon_i ,$$

where  $i$  denotes the individual,  $j$  the state or city, and  $t$  time. Individual log weekly wages  $Y_{ijt}$  are regressed on state-of-birth to control for migration and year-of-birth dummies  $X'_i$ , state or city of residence  $\delta_j$ , census-year effects  $\delta_t$ , state or city average schooling  $\bar{S}_{jt}$  to measure the social benefit, individual schooling  $s_i$ , and a state-year error component  $u_{jt}$ . The largest technical problem in this equation is the likely endogeneity of  $\bar{S}$  and  $s$  due to unobserved factors affecting both wages and the amount of schooling an individual invests in, or affecting wages as well as the percentage of educated workers in a state or city (2003). For example, economic growth may increase wages and a desire for human capital, or productivity and tastes for human capital may simultaneously change (Acemoglu and Angrist 2000). Other weaknesses identified relate to the specific definition of externality adopted; in particular, positive effects may accrue at a national or firm level of aggregation. Several economists have identified similar manners to calculate human capital externalities, such as the Mincer earnings regression and the constant-composition regression.

While the concept of externalities is not very controversial in economics, its application is. Better understanding human capital externalities could lead to better understanding several economic phenomena. Externalities are difficult to verify and quantify. Economists agree that there is a relationship between human capital and

economic growth. The idea of human capital externalities is well established, and consensus exists that human capital investment generates additional indirect economic benefits. However, the concept of human capital externalities remains largely untested because it is difficult to verify and quantify their returns. Furthermore, it has proven difficult to compare externalities over time and between different geographic areas.

Multiple standards of measurement have resulted in various methods of calculating human capital and human capital externalities, causing further difficulty in comparing existing research. Since human capital is abstract, proxies, such as years of schooling, are used to measure human capital. The use of proxies generates difficulties in comparing works because various unique proxies exist for measuring human capital. Furthermore, the efficiency of proxies is questionable and varies from proxy to proxy (Sianesi 2003).

Another issue in measuring human capital arises in cross-country analysis. To form a common measurement for analysis across various countries, one must constrain education to be homogeneous across those countries or limit the sample size to already homogenous countries, such as OECD countries. A disadvantage to homogenizing human capital and grouping similar countries for analysis is assuming training and schooling is the same, which may distort any results.

## Analysis

An individual's accumulated human capital is an important determinant of the wage, but it is not the only factor. The human capital of persons with whom the individual interacts can also affect the individual's wage through externalities. Strong positive externalities increase productivity and wage, while strong negative externalities depress productivity and wage. Modest externalities result in negligible differences in both productivity and wage.

Most economists use the Mincer Regression to measure the strength of human capital externalities, which can be described as:

$$\log y = \log y_0 + rS + \beta_1 X + \beta_2 X^2 + C + \varepsilon ,$$

where  $y$  is earnings ( $y_0$  is the earnings of an individual with no education or experience),  $\log y_0$  is a constant,  $S$  is years of schooling,  $r$  is an externally determined return on an additional year of schooling,  $X$  is years of work experience,  $C$  captures exogenous influences to ensure the coefficient estimates on the relevant variables are unbiased, and  $\varepsilon$  is the error term. The equation shown is a standard Mincer earnings function. To estimate externalities, economists add a term for the average level of education and test if the coefficient of average level of education is statistically different from zero.

The Mincer Regression has become one of the most common methods to estimate wage determination for several reasons. First, the equation is based on a formal model of human capital investment. The portion of the equation that calculates

the determinant of schooling on wage is an equilibrium condition where rational persons invest in human capital to maximize the present value of future earnings.<sup>1</sup> The model is completed by adding post-schooling work experience as a second determinant to wage. Another reason is the Mincer Regression fits data well in most contexts. The equation conforms to the notion that earnings grow as a concave function of age and that earning profile is steeper for workers with more schooling. Log earnings are not an entirely separable function of education and age; there is a different rate of return to education for each age group, rather than a universal return (Lemieux 2003). Introducing potential experience into the model, in place of age, allows the model to capture the shape and slope of the age-earnings profile.

The Mincer earnings function was an attempt to explain wage equilibrium and was later adapted to estimate human capital externalities. In order to determine externalities with the Mincer equation, it is necessary to add average education in the geographic area to the regression as an independent variable. Acemoglu and Angrist use this approach in “How Large Are Human-Capital Externalities? Evidence from Compulsory Schooling Laws” (2000).

Despite the many benefits of the Mincer Regression, it potentially produces biased results when estimating externalities due to ignoring distributional effects of human capital. Consider a segmented working market with no externalities, where one group of workers has masters’ degrees and the other group has a high school education.

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<sup>1</sup>  $\log y = \log y_0 + rS$  captures the effect of schooling on wage.

These two groups do not interact in the same labor market. If the workers with high school education leave the city, the supply of high school-educated workers falls, reducing the supply of labor in that market, and increasing wage of workers with a high school education. By assumption, the market for workers with masters' degrees is unaffected. In this example, the average level of education and wages is increasing in the city and this increase is associated with higher wages, on average. Nonetheless, this is not a result of externalities. Yet the Mincer Regression would identify this as evidence of a positive externality, since the equation only picks up the change in average wage, not the change in distribution of human capital caused by the individuals with high-school diplomas exiting the labor market.

A different approach to determining wage and human capital externalities is the Constant-Composition method outlined by Ciccone and Peri (2005). This method captures the changes in average wage, while holding the composition of labor constant over time. Essentially, the constant-composition equation is a basic wage regression equation with the addition of demographic variables to control for changes in the composition of labor. The equation estimated in this paper is given as:

$$\widehat{wage} = \hat{\alpha} + \hat{\beta}_1 educ + \hat{\beta}_2 city + \hat{\beta}_3 age + \hat{\beta}_4 sex + \hat{\beta}_5 maritalstatus + \hat{\beta}_6 timesinterviewed + \hat{\beta}_7 period + \hat{\beta}_8 city\#period + \varepsilon \quad (1)$$

The dependent variable of the analysis is *wage*, or income per hour. The independent variables are *educ*, *city*, *age*, *male*, *maritalstatus*, *Timesinterviewed*, *period*, and *city#period*. *Educ* is the level of educational attainment. *Period* represents the time-

period in which the data was collected. Although the workforce composition cannot be held constant over time to prevent individuals from entering or exiting the labor market, one can focus on one demographic group to make comparison over time easier. *City* controls for differences in human capital between metropolitan areas in Mexico.<sup>2</sup> *Timesinterviewed* is a control to negate bias created by individuals who have participated in the survey more than once, and *city#period* is an interaction term between the city and time period to prevent time period variables from picking up the average effect across all cities, and  $\varepsilon$  is the error term.

The author collected data for the above variables from the Encuesta Nacional de Empleo<sup>3</sup> (ENE) commissioned by the Instituto Nacional de Estadística y Geografía<sup>4</sup> (INEGI) of Mexico. The data spans from 1995 to 2004 and was collected quarterly, except for the years 1995 to 2000.<sup>5</sup> The INEGI only published the ENE and associated literature in Spanish. This presented a unique challenge since the author needed to translate the dataset and large portions of the literature before continuing the analysis. Furthermore, many of the variables in the ENE were vaguely defined. As a result, the author contacted several individuals at the INEGI to clarify variable definitions. A third problem with the ENE was the data's format. The order of variables was not consistent

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<sup>2</sup> 1 Mexico City, 2 Guadalajara, 3 Monterrey, 4 Puebla, 5 León, 6 San Luís Potosí, 7 Mérida, 8 Chihuahua, 9 Tampico, 10 Veracruz, 12 Acapulco, 13 Aguascalientes, 14 Morelia, 15 Toluca, 16 Saltillo, 17 Villahermosa, 18 Tuxtla, 19 Gutiérrez, 21 Tijuana, 24 Culiacán, 25 Hermosillo, 26 Durango, 27 Tepic, 28 Campeche, 29 Cuernavaca, 31 Oaxaca, 32 Zacatecas, 33 Colima, 36 Querétaro, 39 Tlaxcala, 40 La Paz, 41 Cancún, and 43 Pachuca

<sup>3</sup> National Employment Survey

(<http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/hogares/historicas/ene/>)

<sup>4</sup> National Institute of Statistics and Geography

<sup>5</sup> The INEGI collected data for the ENE tri-annually in the year 2000 and annually for the years 1999 through 1995.



in different survey periods. In addition, variables were often switched between string and numeric formatting in different periods. Once the author translated the ENE, clarified the variables, and formatted and appended the datasets, the author proceeded to analyze the data for evidence of human capital externalities.

The purpose of equation (1) is to generate a prediction of the average wage for workers with the same level of education and the same demographics in each city over time. Using the coefficients estimated in the regression above, the equation calculated the average wage for the first and last period of the ENE survey. The author controls for married male individuals with a high school education, because this group exhibits less variation in the labor market<sup>6</sup>. Subsequently, regressing the change in the wage for the average worker on the change in the average level of education in the particular city allows one to see whether the average level of education can explain the change in the average wage in a that city over time, while holding the composition of labor constant.

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<sup>6</sup> In the data, “secundaria completa” is represented by the variable educ3, and translates to secondary studies completed, or in other words the equivalent of a high school diploma or GED in Mexico

Using equation (1) and data gathered from the ENE, the author produced the results in the following table:

Table 1: Equation (1) Results

Number of obs. =	3577546
F(141, 3577404) =	10346.52
Prob > F =	0.0000
R-squared =	0.2897
Adj R-squared =	0.2896

Variable	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Constant	1.727099	0.0029972	576.23	0.000	1.721225	1.732974
educ <sup>7</sup>						
1	--	--	--	--	--	
2	.3142462	.0013094	239.98	0.000	.3116797	.3168126
3	.5219998	.0013411	389.24	0.000	.5193713	.5246282
4	1.031627	.0013323	774.35	0.000	1.029015	1.034238
Firstperiod	.020425	332.1875	0.00	1.000	-651.0553	651.0962
Lastperiod	.0096003	.0066721	1.44	0.150	-.0034767	.0226773
male	.0622944	.0008649	72.03	0.000	.0605992	.0639896
married	.1715245	.0008746	196.11	0.000	.1698103	.1732388
timesinterviewed	.016113	.0002729	59.05	0.000	.0155782	.0166478
Age	.0075687	.0000342	221.40	0.000	.0075017	.0076357

\*Table 3 in the Appendix includes the city and city#period variables.

With the results from the regression equation, the author calculated the average *wage* for each metropolitan area in the first and last period; then, tabulated the mean for *yrsofschool*, the total number of years an individual enrolled in school, and *employment*, the number of employed individuals in the labor market, in both the first and last period. With the average wage, years of schooling, and number of employed individuals, the author calculated the change in the variables between 1995 and 2004. The change in wage for each metropolitan area was calculated by the equation:

$$\Delta \widehat{wage} = \widehat{wage}_{2004} - \widehat{wage}_{1995} . \quad (2)$$

<sup>7</sup> Education is presented by a set of dummy variables where 1–incomplete primary education, 2–primary education completed, 3–secondary education completed, 4–tertiary or superior education completed

The author then performed a similar calculations for the variables *yrsofschool* and *employment*. This created the variables  $\Delta\widehat{wage}$ ,  $\Delta\widehat{yrsofschool}$ , and  $\Delta\widehat{employment}$ , which represent the change in average wage, the average number of years an individual enrolled in school, and the average number of employed individuals in the labor market for each metropolitan area. The author then regressed  $\Delta\widehat{wage}$  on  $\Delta\widehat{yrsofschool}$  and  $\Delta\widehat{employment}$  to test for human capital externalities, expressed as:

$$\Delta\widehat{wage} = \hat{\beta}_1\Delta\widehat{yrsofschool} + \hat{\beta}_2\Delta\widehat{employment} . \quad (3)$$

The results of equation (3) are listed in the following table: Table 2.

Table 2: Equation (3) Results						
Number of obs. = 31						
F(2, 28) = 1.22						
Prob > F = 0.3096						
R-squared = 0.0803						
Adj R-squared = 0.0146						
Variable	Coef.	Std. Err.	T	P> t	[95% Conf. Interval]	
Constant	1.15713	.0265966	43.51	0.000	1.102649	1.211611
<i>yrsofschool</i>	.0583427	.0385946	1.51	0.142	-.0207149	.1374003
<i>employment</i>	-1.464684	.9864597	-1.48	0.149	-3.485355	.5559872

Substituting the coefficient values for  $\Delta\widehat{yrsofschool}$  and  $\Delta\widehat{employment}$  into the regression equation produces the following equation:

$$\Delta\widehat{wage} = 1.16 + .06 * \Delta\widehat{yrsofschool} - 1.46 * \Delta\widehat{employment} . \quad (4)$$

The p-value for the regression equation on  $\Delta\widehat{yrsofschool}$  is 0.142. Thus, it is not statistically significant with all other variables held constant, indicating there is no evidence of human capital externalities present in Mexico.

## Concluding Remarks

Past literature on human capital has used the Mincer Regression to estimate human capital externalities. In “Identifying Human-Capital Externalities: Theory with Application”, Ciccone and Peri test for externalities in the United States using both the Mincer Regression and Constant-Composition approaches. Ciccone and Peri demonstrated bias in the Mincerian approach with new empirical work and formulated another method, the Constant-Composition approach, to estimate human capital externalities without the bias potentially created by the Mincer Regression. In their paper, the Mincer equation indicated the presence of human capital externalities in the United States. Analysis of human capital externalities with the Constant-Composition approach failed to indicate the existence of any externalities.

Since Ciccone and Peri only applied the Constant-Composition approach to the United States and no other empirical work has applied the approach to different economies, this raises questions as to the effectiveness of the Constant-Composition approach to estimate human capital externalities in an economy that is distinct from the United States. For example, economic differences, such as poverty rates, between the United States and Mexico could influence the data and produce distinct results in each country. Furthermore, one could argue Ciccone and Peri’s results are unique to their dataset. In other words, empirical work emulating Ciccone and Peri’s method with different data could produce different results. For example, a larger sample with a different geographic distribution could produce contrary results.

Using the Constant-composition approach, the author did not find any evidence of human capital externalities in Mexico. These findings, which are consistent with those of Ciccone and Peri, confirm the results are not unique to the United States or to Ciccone and Peri’s data (2005). The fact the author reached a similar conclusion for Mexico suggests the

Constant-Composition approach functions for economies regardless of their position on the growth curve, although additional empirical work to include a wider array of countries at different levels of economic development is needed to further confirm this theory.

## Appendix

Table 3: Equation (1) Results

Number of obs =	3577546
F(141, 3577404) =	10346.52
Prob > F =	0.0000
R-squared =	0.2897
Adj R-squared =	0.2896

Variable	Coef.	Std. Err.	T	P> t	[95% Conf. Interval]	
Constant	1.727099	0.0029972	576.23	0.000	1.721225	1.732974
educ						
1	--	--	--	--	--	
2	.3142462	.0013094	239.98	0.000	.3116797	.3168126
3	.5219998	.0013411	389.24	0.000	.5193713	.5246282
4	1.031627	.0013323	774.35	0.000	1.029015	1.034238
firstperiod						
lastperiod	.020425	.332.1875	0.00	1.000	-651.0553	651.0962
	.0096003	.0066721	1.44	0.150	-.0034767	.0226773
male						
	.0622944	.0008649	72.03	0.000	.0605992	.0639896
married						
	.1715245	.0008746	196.11	0.000	.1698103	.1732388
timesinterviewed						
	.016113	.0002729	59.05	0.000	.0155782	.0166478
age						
	.0075687	.0000342	221.40	0.000	.0075017	.0076357
a met						
1	--	--	--	--	--	
2	.1404326	.0035755	39.28	0.000	.1334248	.1474403
3	.2157291	.0033933	63.57	0.000	.2090783	.2223799
4	-.1086746	.0036059	-30.14	0.000	-.1157421	-.1016071
5	.150345	.0032839	45.78	0.000	.1439085	.1567814
6	.0136299	.0036334	3.75	0.000	.0065086	.0207511
7	-.059932	.0038121	-15.72	0.000	-.0674036	-.0524603
8	-.2077996	.0038311	-54.24	0.000	-.2153085	-.2002907
9	.1608372	.0041208	39.03	0.000	.1527605	.1689139
10	-.0505233	.0038994	-12.96	0.000	-.0581661	-.0428806
11	-.4251823	.0041563	-102.30	0.000	-.4333285	-.417036
12	-.1577873	.0039922	-39.52	0.000	-.1656118	-.1499627
13	-.2749289	.003994	-68.83	0.000	-.2827571	-.2671007
14	.0014164	.0040215	0.35	0.725	-.0064657	.0092984
15	-.0100184	.0039187	-2.56	0.011	-.017699	-.0023378
16	-.0133857	.0039734	-3.37	0.001	-.0211735	-.0055979
17	.1302428	.00382	34.09	0.000	.1227557	.137730
18	-.0150511	.0037976	-3.96	0.000	-.0224943	-.0076079
19	-.2508837	.0038549	-65.08	0.000	-.2584392	-.2433281
20	.2115354	.0042115	50.23	0.000	.203281	.2197898
21	.4859825	.0037507	129.57	0.000	.4786312	.4933337
22	.1690402	.0041852	40.39	0.000	.1608374	.1772431
23	.213584	.0042549	50.20	0.000	.2052445	.2219235
24	.0916332	.003737	24.52	0.000	.0843087	.0989577
25	.1363184	.0038769	35.16	0.000	.1287199	.1439169
26	-.0610862	.0039177	-15.59	0.000	-.0687647	-.0534077
27	-.1148346	.0038825	-29.58	0.000	-.1224442	-.107225
28	-.2820605	.0039186	-71.98	0.000	-.2897409	-.2743801
29	-.1161029	.0043706	-26.56	0.000	-.1246692	-.1075366
30	-.2008633	.004412	-45.53	0.000	-.2095107	-.1922159
31	-.2005613	.003863	-51.92	0.000	-.2081327	-.192990
32	-.0901314	.004098	-21.99	0.000	-.0981634	-.0820993
33	-.0519127	.003931	-13.21	0.000	-.0596173	-.0442080
34	.0151757	.0044314	3.42	0.001	.0064903	.0238612

35	-.0576255	.0042819	-13.46	0.000	-.0660178	-.0492332
36	.0809851	.0040104	20.19	0.000	.0731248	.0888454
37	-.0450021	.0038263	-11.76	0.000	-.0525015	-.0375026
38	-.0419636	.0038591	-10.87	0.000	-.0495274	-.0343998
39	-.35461	.0038575	-91.93	0.000	-.3621705	-.3470494
40	.1277425	.0041105	31.08	0.000	.119686	.1357990
41	.05418	.0041979	12.91	0.000	.0459522	.0624078
42	.1011307	.0043046	23.49	0.000	.0926937	.1095676
43	-.0064791	.0039729	-1.63	0.103	-.0142659	.0013077
44	.4464123	.0037986	117.52	0.000	.4389671	.4538574
45	.0785676	.0043584	18.03	0.000	.0700252	.0871099
46	.277272	.0049579	55.92	0.000	.2675547	.2869894
47	-.0545807	.0049335	-11.06	0.000	-.0642502	-.0449112
48	-.1704247	.0055337	-30.80	0.000	-.1812706	-.1595788
81	.009508	.0034759	2.74	0.006	.0026953	.0163207
82	-.2389916	.0028957	-82.53	0.000	-.2446671	-.2333161
83	-.3566372	.0027508	-129.65	0.000	-.3620287	-.3512457
84	-.4722185	.0026197	-180.26	0.000	-.4773529	-.4670840
85	-.1398717	.0061513	-22.74	0.000	-.1519281	-.1278153
86	-.3168023	.0036692	-86.34	0.000	-.323993	-.3096107
a met#firstperiod						
1#1995 2	-.8760154	332.1875	-0.00	0.998	-651.9518	650.1997
2#1995 2	-1.009694	332.1875	-0.00	0.998	-652.0854	650.0660
3#1995 2	-.9391711	332.1875	-0.00	0.998	-652.0149	650.1366
4#1995 2	-.9273993	332.1875	-0.00	0.998	-652.0031	650.1483
5#1995 2	-.9720484	332.1875	-0.00	0.998	-652.0478	650.1037
6#1995 2	-1.008046	332.1875	-0.00	0.998	-652.0838	650.0677
7#1995 2	-1.102733	332.1875	-0.00	0.997	-652.1785	649.9730
8#1995 2	-.8368008	332.1875	-0.00	0.998	-651.9125	650.2389
9#1995 2	-1.029977	332.1875	-0.00	0.998	-652.1057	650.0458
10#1995 2	-.9718691	332.1875	-0.00	0.998	-652.0476	650.1039
11#1995 2	-.7952585	332.1875	-0.00	0.998	-651.871	650.2805
12#1995 2	-.9662142	332.1875	-0.00	0.998	-652.042	650.1095
13#1995 2	-.9287555	332.1875	-0.00	0.998	-652.0045	650.1470
14#1995 2	-.9897684	332.1875	-0.00	0.998	-652.0655	650.0860
15#1995 2	-1.03622	332.1875	-0.00	0.998	-652.112	650.0395
16#1995 2	-.9865594	332.1875	-0.00	0.998	-652.0623	650.0892
17#1995 2	-1.026998	332.1875	-0.00	0.998	-652.1027	650.0487
18#1995 2	-1.023806	332.1875	-0.00	0.998	-652.0995	650.0519
19#1995 2	-.9641049	332.1875	-0.00	0.998	-652.0398	650.1116
20#1995 2	-1.053414	332.1875	-0.00	0.997	-652.1292	650.0223
21#1995 2	-1.151767	332.1875	-0.00	0.997	-652.2275	649.9240
22#1995 2	-.8666908	332.1875	-0.00	0.998	-651.9424	650.2091
23#1995 2	-.9584764	332.1875	-0.00	0.998	-652.0342	650.1173
24#1995 2	-1.100887	332.1875	-0.00	0.997	-652.1766	649.9749
25#1995 2	-.8938365	332.1875	-0.00	0.998	-651.9696	650.1819
26#1995 2	-.9892154	332.1875	-0.00	0.998	-652.065	650.0865
27#1995 2	-.9224511	332.1875	-0.00	0.998	-651.9982	650.1533
28#1995 2	-.8495066	332.1875	-0.00	0.998	-651.9252	650.2262
29#1995 2	-.831143	332.1875	-0.00	0.998	-651.9069	650.2446
30#1995 2	-1.163458	332.1875	-0.00	0.997	-652.2392	649.9123
31#1995 2	-.9539398	332.1875	-0.00	0.998	-652.0297	650.1218
32#1995 2	-.9919741	332.1875	-0.00	0.998	-652.0677	650.0838
33#1995 2	-.8216468	332.1875	-0.00	0.998	-651.8974	650.2541
34#1995 2	-.9931375	332.1875	-0.00	0.998	-652.0689	650.0826
35#1995 2	-.9617373	332.1875	-0.00	0.998	-652.0375	650.1140
36#1995 2	-.9531911	332.1875	-0.00	0.998	-652.0289	650.1226
37#1995 2	-.9424105	332.1875	-0.00	0.998	-652.0182	650.1333
38#1995 2	-1.081768	332.1875	-0.00	0.997	-652.1575	649.9940
39#1995 2	-.9255188	332.1875	-0.00	0.998	-652.0013	650.1502
40#1995 2	--	--	--	--	--	--
41#1995 2	--	--	--	--	--	--
42#1995 2	--	--	--	--	--	--
43#1995 2	--	--	--	--	--	--
44#1995 2	--	--	--	--	--	--
45#1995 2	--	--	--	--	--	--

46#1995 2	--	--	--	--	--
47#1995 2	--	--	--	--	--
48#1995 2	--	--	--	--	--
81#1995 2	--	--	--	--	--
82#1995 2	--	--	--	--	--
83#1995 2	--	--	--	--	--
84#1995 2	--	--	--	--	--
85#1995 2	--	--	--	--	--
86#1995 2	--	--	--	--	--
a met#lastperiod					
1#2004 4	.1717315	.0134997	12.72	0.000	.1452725 .1981905
2#2004 4	.2317678	.0169179	13.70	0.000	.1986094 .2649262
3#2004 4	.164316	.0150818	10.89	0.000	.1347561 .1938759
4#2004 4	.2056693	.01634	12.59	0.000	.1736434 .2376951
5#2004 4	.1715824	.0146082	11.75	0.000	.1429508 .2002139
6#2004 4	--	--	--	--	--
7#2004 4	.2312544	.0178601	12.95	0.000	.1962493 .2662595
8#2004 4	.2580985	.01773	14.56	0.000	.2233484 .2928487
9#2004 4	.1949263	.0199063	9.79	0.000	.1559108 .2339419
10#2004 4	.2112744	.0192847	10.96	0.000	.1734771 .2490717
11#2004 4	--	--	--	--	--
12#2004 4	.211607	.0212645	9.95	0.000	.1699293 .2532846
13#2004 4	.2089731	.0197165	10.60	0.000	.1703293 .2476168
14#2004 4	.1996418	.0196015	10.19	0.000	.1612236 .2380599
15#2004 4	.2518782	.0182613	13.79	0.000	.2160867 .2876698
16#2004 4	.1343332	.0190785	7.04	0.000	.0969400 .1717264
17#2004 4	.1651394	.0189697	8.71	0.000	.1279595 .2023194
18#2004 4	.2160579	.0179391	12.04	0.000	.1808979 .2512179
19#2004 4	.2149784	.0181383	11.85	0.000	.1794281 .2505288
20#2004 4	--	--	--	--	--
21#2004 4	.1596814	.0180522	8.85	0.000	.1242996 .1950632
22#2004 4	--	--	--	--	--
23#2004 4	--	--	--	--	--
24#2004 4	.2172902	.0172598	12.59	0.000	.1834616 .2511187
25#2004 4	.1574849	.0183007	8.61	0.000	.1216161 .1933536
26#2004 4	.1067267	.0183655	5.81	0.000	.070731 .1427223
27#2004 4	.2506016	.0181158	13.83	0.000	.2150952 .2861079
28#2004 4	.2367771	.0194721	12.16	0.000	.1986125 .2749416
29#2004 4	.2019896	.0231365	8.73	0.000	.1566428 .2473364
30#2004 4	--	--	--	--	--
31#2004 4	.2475613	.0180793	13.69	0.000	.2121264 .2829961
32#2004 4	.2378601	.0203457	11.69	0.000	.1979833 .2777369
33#2004 4	.2274011	.0185915	12.23	0.000	.1909624 .2638397
34#2004 4	--	--	--	--	--
35#2004 4	--	--	--	--	--
36#2004 4	.2009579	.0204218	9.84	0.000	.1609320 .2409838
37#2004 4	.185678	.0190225	9.76	0.000	.1483945 .2229615
38#2004 4	.2191921	.0180534	12.14	0.000	.1838080 .2545762
39#2004 4	.2274126	.0183264	12.41	0.000	.1914935 .2633317
40#2004 4	.2436826	.0201088	12.12	0.000	.2042702 .2830951
41#2004 4	.2183964	.0181468	12.04	0.000	.1828294 .2539634
42#2004 4	--	--	--	--	--
43#2004 4	.1595795	.0185184	8.62	0.000	.1232841 .1958749
44#2004 4	--	--	--	--	--
45#2004 4	--	--	--	--	--
46#2004 4	--	--	--	--	--
47#2004 4	--	--	--	--	--
48#2004 4	--	--	--	--	--
81#2004 4	.2336856	.0115289	20.27	0.000	.2110893 .2562818
82#2004 4	.3569625	.0159205	22.42	0.000	.3257589 .3881660
83#2004 4	.4317157	.0121776	35.45	0.000	.407848 .4555835
84#2004 4	.4097755	.0120186	34.09	0.000	.3862194 .4333316
85#2004 4	.0195232	.0149588	1.31	0.192	-.0097956 .0488420
86#2004 4	--	--	--	--	--



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